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Circular No. 32 - Feeding Farm Animals

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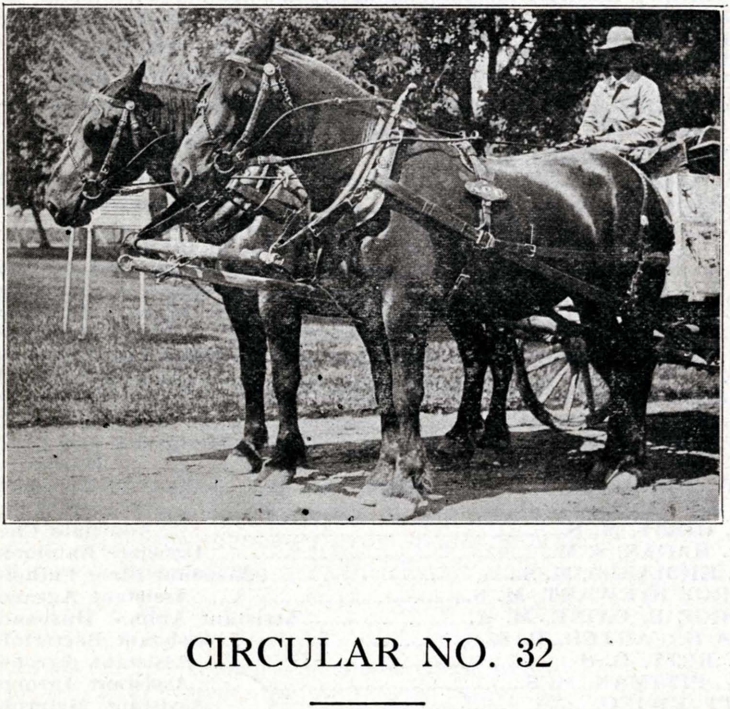

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UTAH AGRICULTURAL EXPERIMENT STATION

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By W. E. CARROLL

HISTORICAL

Our oldest history tells us that in the beginning man was given dominion "over the cattle, and over all the earth." This was of course only potentially possible at first, and could not be realized until man developed and exercised his intelligence to this end. What, then, does it mean to have dominion over the cattle? Is this not merely to control them and direct their energies and productivity to the happiness of mankind? Surely this is so, and that man has greatest dominion who can control them most completely for the good of the race.

Whether there was in the beginning a definite placing of the animals under man's control, as outlined in the "Good Book," matters not. The result is the same, for man indeed has "dominion over them." So complete is this dominion that in many cases they can not now live without him.

Animals no doubt knew man first as an enemy, when he hunted them for the food and clothing they could supply. Later he probably realized the advantage of having them more easily accessible and began restricting their wanderings and herding them in small groups around him. This made it necessary for him to seek out fresh pastures as the old ones were fed off, and resulted in a wandering or nomadic life.

As time went on it was only natural for him to observe that some pastures were relished more by the animals than others and that such pastures increased growth and production. This observation was the beginning of intelligent and successful feeding.

From here it was only a step to selecting all good pastures as far as possible, and then to cultivating the desirable plants in patches by themselves. This made possible the harvesting and storing of feeds for winter, and with such a supply of feed available it was no longer necessary for man to drive his flocks and herds to feed. This was the first step toward a permanent location and the highly developed agricultural life of today.

This, briefly, is how man has realized his heritage and has acquired "dominion over the cattle."

KNOWLEDGE NECESSARY TO SUCCESS

The present practice of successful feeding is based upon rather definite laws which are the outgrowth of long practical experience coupled with many carefully conducted feeding experiments. Close acquaintance with these laws is highly desirable for all feeders and almost a necessity for the success of the majority. An occasional untrained man is highly successful as a feeder of livestocfl With these rare exceptions, intense love of their calling is the guide whic pilots them aright. The average man, however, must rely on his knowledge rather than on his intuition.

HOW FEEDS ARE USED

The feed consumed by an animal is used in its body for one of three purposes: (1) construction of new tissues, as in growth and the production of milk; (2) repair of worn out portions of the body; and, (3) the production of heat and other energy with which the body keeps warm and does its work. When put to this last use the food substances are burned in the body very much as a flame would burn them only much more slowly.

RELATION BETWEEN THE FEED AND THE PRODUCT

All substances produced by the animal (meat, milk, wool, etc.) are direct products of the feed consumed. This being the case, it is not surprising to find a similarity in composition between the feed and the animal product. The similarity, however, is not so great as might be expected on first thought. It is true that plants and other animal feeds are made up of the same chemical substances as compose the animal products, but these substances occur in very different proportions in the two.

COMPOSITION OF FEEDS

All plant and animal products can be separated into water and dry matter. Even the apparently driest materials such as hay, grain, or even flour contain appreciable quantities of water. The dry matter is composed in all cases of the following groups of chemical substances: protein, carbohydrates, fats, nitrogen-free extract, and ash. Representatives of each of these groups are spoken of as food nutrients.

FUNCTION OF FOOD NUTRIENTS

In the animal body each food nutrient performs a special function.

Protein is used by the animal chiefly in the construction of new muscular material and blood, and in the manufacture of milk. In fact it occurs in every cell of the body and must be supplied for the repair of these protein tissues as they are worn out by the work of the various parts and organs of the body.

It may also be used as fuel within the body for the production of heat and energy; and portions of the protein molecule may be transformed into fat and stored.

The peculiar thing about protein is that as building and repair material it cannot be replaced by any other food nutrient. For the production of heat and energy, however, carbohydrates, fats and nitrogen-free extract are interchangeable with it.

All feeds contain protein, but in varying amounts. As examples of high-protein grain feeds may be mentioned cottonseed meal and linseed oil meal, which contain about 40 and 35 per cent, respectively. In the following list is given in per cent the protein content of some of the common feeds:*

Corn	10.4	Wheat bran	11.9 to 16.0
Wheat	9.9 to 13.3	Alfalfa hay	13.9 to 15.9
Oats	12.4	Clover Hay	11.6 to 13.2
Barley	10.8 to 12.7	Timothy hay	5.2 to 9.8

*Henry and Morrison, Feeds and Feeding.

As examples of nearly pure protein may be mentioned the white of egg, lean meat fibres, blood clots, and milk curd. Of course, each of these as commonly seen contains large proportions of water and smaller amounts of other substances. Protein does not occur in such pure form in any quantity in the common plants.

Carbohydrates are used by the animal for the production of heat and other forms of energy within the body, or they may be stored in the body, in very limited amounts, as the animal carbohydrate, glycogen, or in milk as lactose or milk sugar, or further they may be transformed into fat and stored in the body as such in rather large quantities, or appear as butterfat in the milk.

Plants contain much higher proportions of carbohydrates than of any other food nutrient. In fact, this is true of practically all feeds except those of animal origin, such as milk, tankage, and fish and meat meals.

The following table gives the percentage amount of carbohydrates in the feeds listed:*

	Total Carbohydrates			Total Carbohydrates	
Feed	crude fibre	N-free extract	Feed	crude fibre	N-free extract
Corn	2.0	70.9	Wheat bran	9.5	53.7
Wheat	2.2	71.2	Alfalfa hay	28.3	37.3
Oats	10.9	59.6	Clover hay	27.3	36.9
Barley	4.6	69.8	Timothy	29.9	45.0

*Henry and Morrison, Feeds and Feeding.

In this table it will be noted that the carbohydrates are divided into two classes, crude fibre and nitrogen-free extract. The crude fibre is the woody portion of the feeds and is for the most part undigestible. A certain amount of crude fibre, varying with the class of animals fed, is desirable in order to give bulk to the ration. Too much, however, taxes the digestive organs unnecessarily and makes the ration so bulky that the animal cannot consume enough to keep up its body processes.

In general, the grains contain very little crude fibre while the hays contain much more and the straws and fodders contain still more.

As examples of carbohydrates may be given sugar, starch, cotton fibre, and some kinds of paper. The last two are mostly cellulose and crude fibre, both of which are undigestible.

Nitrogen-free extract, while not identical with carbohydrates, can be considered as having the same use in the body.

Fats of the feed are put to practically the same uses in the animal body as carbohydrates. Fats, however, yield 2.25 times more energy than the same weight of carbohydrates.

Only a very small proportion of the ordinary feed is fat. The cereal grains contain from 1 to 5 per cent fat, hays and fodders from less than 1 to 4 per cent.

All the common fats—lard, butter fat, tallow, etc.—are good examples of this class of nutrients.

Ash or the mineral matter of feeds is the part remaining after complete burning of any plant or animal tissue. It is found in only very small amounts in most plants and animals. Bones, however, are composed very largely of ash. Mineral matter of some kind occurs in every living cell and is absolutely essential to life. With the exception of common salt it, however, is present in the common western feeding stuffs in sufficient amounts for most animals. Corn is rather defficient in some kinds of mineral matter and where hogs are being fed on corn alone for any great length of time some additional mineral matter is necessary. Usually raw rock phosphate is found sufficient in this case.

DIGESTION OF FEEDS

Before any feed can be of use to the animal it must be dissolved in order that it can pass through the walls of the digestive organs into the blood. This dissolving process to which the feed is submitted in the mouth, stomach, and intestines is called digestion.

None of the ordinary feeds are completely dissolved in the processes of digestion, neither is any one nutrient in these feeds completely digested. Parts of the nutrients seem to be so well protected by the undigestible crude fibre that they escape digestion. The amount digested varies from less than 50 per cent to as high as 98 per cent of the total feed. The coarse rough feeds containing high percentages of crude fibre are less completely digested than are the grains. In general, from 75 to 85 per cent of the total dry matter of grains is digested, 55 to 65 per cent of grass hays, and 60 to 70 per cent of alfalfa and clover hays.

BALANCED RATIONS

The calculation of a balanced ration for any given animal necessitates a knowledge of the requirements of the animal and an understanding of the composition of the feeds to be used. To determine the feed requirements of animals has been the work of many years of careful experimentation. These feed requirements of the various classes of animals are known as "Feeding Standards," and give in a general way the amount of total feed and of the various nutrients necessary during twenty-four hours for a given animal under stated conditions. Feeding Standards must be looked upon as guides only, which require change accocrding to the individual demands of the animal being fed.

Tables I to IV inclusive in the appendix give Feeding Standards for the various classes of farm animals, while Tables V, VI and VII give for rumniants, horses and swine respectively the amount of digestible protein and the therms of energy in the common Western feed stuffs. A therm is a measure of energy just as a pound is a measure of weight. From these data it is possible to calculate a balanced ration for any of the farm animals. The few rations which follow are not given as ideals for the animals, but are used to illustrate the method of computing rations.

Suppose it is desired to calculate a ration for a 750-pound fattening steer. By reference to Table II it is found that such an animal during the early fattening period requires 1.06 pounds of digestible true protein and 9.95 therms of net energy daily. Suppose further that a ration is assumed of 20 pounds of alfalfa hay and 5 pounds of a grain mixture composed of equal parts by weight of wheat bran and rolled barley. These amounts of the feeds are found by reference to Table V of the appendix to contain the following:

	Digestible True Protein	Net Energy
	Pounds	Therms
20 pounds alfalfa hay	1.42	6.85
2.5 pounds wheat bran	0.27	1.32
2.5 pounds rolled barley	0.21	2.25
Total	1.90	10.42
Feeding Standard	1.06	9.95

This assumed ration is seen to be considerably high in protein and somewhat high in net energy. By changing the ration to feed 10 pounds of alfalfa hay, 15 pounds of corn silage, and 5 pounds of dent corn the figures are as follows:

	Digestible True Protein	Net Energy
	Pounds	Therms
10 pounds alfalfa hay	0.71	3.42
15 pounds corn silage	0.09	2.38
5 pounds dent corn	0.35	4.27
Total	1.15	10.07
Feeding Standard	1.09	9.95

This ration, though not corresponding exactly with the requirements of the Feeding Standard, approaches it so closely that further calculation would probably not be necessary.

For the next example assume the calculation of a ration for a 1000-pound dairy cow giving 35 pounds of 4.5 per cent milk. The Feeding Standard for such a cow calls for the following:

	Digestible True Protein	Net Energy
	Pounds	Therms
For maintenance of 1000-lb. cow	0.50	6.00
For 35 pounds of 4.5 per cent milk	1.82	10.18
Total	2.32	16.18

A ration composed of 30 pounds of alfalfa hay and 10 pounds of wheat bran would supply 3.21 pounds of digestible true protein and 15.6 therms of net energy. This is nearly 1 pound more protein than is required and about 0.6 of a therm less net energy than the standard calls for. To correct this condition some feeds less rich in protein should be combined with the alfalfa hay. A ration composed of 25 pounds of alfalfa hay, 20 pounds of corn silage, and 6 pounds of corn meal meets the requirement very well as shown below.

	Digestible True Protein	Net Energy
	Pounds	Therms
25 pounds alfalfa hay	1.77	8.55
20 pounds corn silage	0.12	3.18
6 pounds corn meal	0.38	5.11
Total	2.27	16.84
Feeding Standard	2.32	16.18

The agreement between the standard and the ration in this case is very close.

When the method is fully understood as outlined above and illustrated by the examples given, little difficulty will be experienced in applying it to any set of practical conditions. Practice will bring the desired speed in the actual calculation of rations.

CHARACTERISTICS OF A GOOD RATION

Adapted to Species.—A good ration must be adapted to the species of animals being fed. That is, a horse should be fed a different ration from that given a cow, while sheep and hogs should each be fed still different rations.

One reason for this is seen when it is remembered that the stomach of a horse has an average capacity of 19 quarts, whereas a cow has four stomachs with a total capacity of 266 quarts. The stomach of a hog, on the average, can contain 8.5 quarts, but sheep, which are even smaller in size, have four stomachs with a total capacity of 31 quarts.

These differences suggest immediately that cattle and sheep are equipped to handle bulkier rations than horses and hogs. This is indeed true, for practical experience and experimental work have demonstrated that cattle and sheep do better than horses and hogs when all are fed entirely on the coarser and rougher hays, straws, and fodders.

For equal success, then, in feeding horses and hogs as compared with cattle and sheep, a larger proportion of grain must be fed the former.

Palatable.—A good rataion must be palatable or animals will not consume enough of it to do well. One of the best ways of making a ration palatable is to make it up of a variety of feeds.

Animals enjoy variety as well as do people. Imagine the eagerness with which a person would look forward to meal time after about a month on bread, butter, and water three times a day. And yet some go on feeding their animals alfalfa hay and water, or worse, month after month. The only method animals have of showing their lack of approval of such treatment is to eat barely enough of such a ration to keep alive. This of course cuts down production and thereby reduces profits.

Quality of Product.—The ration should be compounded with reference to the quality of the product. No feeds should be given which taint the product or decrease its value in any way. Such an inferior product is not so saleable and must go, if at all, at a reduced price.

Corn alone fed to fattening hogs producecs a soft oily pork of inferior value. Reports have come from some farmers that pork produced and fattened largely on alfalfa pasture has a disagreeable, fishy flavor, but this has not been well verified.

Potatoes fed in too large quantities and for too long a period to dairy cows may taint the milk and give a pale color and salvy texture and appearance to the butter. In the Southern States a soft butter of low melting point is produced because of feeding liberal amounts of cottonseed meal.

Many other examples might be cited, but this general warning should be sufficient: When the feed is known to interfere with the quality of the product the ration should be changed.

Variety.—As a matter of safety, feeds of different origin should enter into the ration. It is possible to make up a palatable, well balanced ration entirely from one plant such as the oat or wheat plant. Temptation to do this is, of course, very rare, especially in the West.

System of Farming.—The ration should conform to the system of farming followed. This adjustment will probably be made by making the cropping system conform to the feeds desired for the livestock. Arrangements should be made to grow all the roughage and most of the grains needed for feeding purposes. Occasionally it is more economical to sell grains grown on the farm and buy mill by-products. Advantage should of course be taken of all such possibilities.

Economical.—With all the other requirements satisfied if the ration cannot be fed at a profit it is useless. Care must be taken to use all the cheap feeds possible.

Liberal.—When the ration conforms to all the above requirements, **feed plenty.** Lack of liberal feeding is the source of reduced profits on many farms. It takes roughly one half of all an animal can eat to maintain its body in good working condition. The folly of feeding, say a three-fourths ration, is then apparent, for two thirds of this ration would be used to maintain the body and only one third could be used for growth or production, whereas on a full ration only one half of the feed would be used for maintenance.

RELATIVE VALUE OF FEEDING STUFFS

The question which probably arises most frequently in the minds of livestock feeders is, "Which kind of grain or hay will be most economical to feed under my conditions?" Unfortunately there is as yet no definite answer to this question in spite of the large amount of experimental time and energy that have been spent toward its solution. There have been worked out three well-recognized methods of comparing the value of feeds (1) digestible matter, (2) net energy values, (3) feed unit system, but neither is without its shortcomings.

(1) The amount of digestible matter feeds contain affect their feeding value, tho the amount of digestible nutrients cannot be taken as the sole guide to the value of feeds. The relative proportion of the nutrients, the kind of animals fed, the east of digestion, palatability, and many other factors must be considered. Barley, for example, contains on the average 79.4 per cent of total digestible nutrients, and choice cottonseed meal 78.2 per cent. As a matter of fact, the cottonseed meal with most animals will feed out to a considerably better advantage than the barley.

(2) The net energy which feeds yield while being utilized in the animal body is used as a measure of their value, but this method if followed closely would again lead to false conclusions. Wheat shorts shows a net energy content of 75.02 therms, and barley yields 89.94 therms for each hundred pounds, while as a matter of fact the shorts has actually a higher feeding value for certain animals—young pigs, for example—than the barley. Oats contain 67.56 therms of net energy and yet the average horse feeder would much rather have 100 pounds of oats than 100 pounds of barley even though the barley does contain over 33 per cent more net energy than oats. Oat straw contains slightly more net energy than alfalfa hay. Yet imagine the inconsistency of this in view of the decided choice made by the

dairy cow and practically all other classes of livestock.

(3) The feed unit system of comparing the feeding value of feeds assumes the feeding value of one pound of corn to be one feed unit. The amount of any other feed required to produce the same results as those produced by one pound of corn is considered one feed unit. Here again oats are listed as being 10 per cent less valuable than barley. Certain other considerations, chiefly the kind of animals and insufficient data, make comparisons by this method not entirely free from error.

In absence of any one satisfactory method of comparing feeds, a combination of the three can be used with much safety. Table VIII has been prepared, using a sliding scale of prices, to show the relative money value of several of the Western feeds. When the price of 100 pounds of the feeds listed is as indicated in column 1 of the table the cost of one pound of digestible matter is given in column 3, the cost of one therm of net energy in column 5, and the cost of one feed unit in column 7 of the table.

It is not supposed that the table will be an absolute guide, but a study of the data there given should aid the average feeder materially in making up an economical ration from the feeds available. In general it is well to keep in mind the following points concerning the three methods of comparison.

Comparisons on the basis of the digestible matter of the various feeds gives an undue advantage to the coarse feeds, such as hays and fodders. Especially is this true when their value for horses or hogs is being considered. These values are therefore probably more nearly correct for mature cattle and sheep than for horses and hogs, or for growing animals.

The net energy values make it appear that feeds of high fat and low protein content, such as corn, are more valuable than they actually are, except possibly where these feeds are being fed to fattening animals, in which case the values seem to be comparatively correct.

The feed unit system can be considered to give rather reliable comparisons of feed values for growing animals, milking cows, and probably hogs.

As an example of how to use the table, suppose it is desired to know which is the more economical, bran at $1.50 a hundred or shorts at $1.60. At these prices the digestible matter of bran is shown in the table to cost 2.46 cents a pound as against 2.05 cents for that in shorts. A therm of net energy costs in the bran 2.83 cents and only 2.13 cents in the shorts, and the cost of one feed unit in the bran is 1.65 cents, whereas in the shorts it is 1.60 cents. According to all three methods then, shorts at $1.60 a hundred is a cheaper feed than bran at $1.50.

If the range in prices is not great enough to include any given set of local prices it may be possible to double a given price or to make a combination of two of the prices listed. For example, if it is desired to compare three dollar barley with wheat at $3.25, the figures for barley at $1.50 can be doubled and those for wheat at $1.25 and $2.00 can be added to arrive at the proper values for comparison.

One caution should be observed in the use of the table: feeds of widely different character do not admit of direct comparison. That is a comparison of a roughage with a concentrate will lead to false conclusions. Grains should be compared with grains and roughages with roughages.

ECONOMICAL CONSIDERATIONS

It is the function of all livestock to produce something of value to mankind—to contribute something to his well being. There seems to be no other excuse for their existence. The horse supplies energy to carry mankind and draws his loads. Cattle, sheep, and hogs contribute meat, milk, and clothing, according to their kind. Animal products are in general very expensive, and this too is not all the fault of the butcher and milkman. The following figures show the amount of grain or its equivalent in other feeds required by each class of animals to produce one pound of edible dry matter for human food:

Dairy Cow, 6.3 pounds.	Sheep, 35 pounds.
Hog, 10 pounds.	Beef Cattle, 41 pounds.

These results may not be absolutely accurate and the method of deriving them is too long to include here. They at least are not sufficiently far from the truth to affect materially the conclusions drawn, and are correct from a comparative standpoint. From these data it can be seen that the equivalent of from 6 to 40 pounds of grain are required to produce one pound of edible dry matter from the different classes of livestock. It will also be noted that the dairy cow, as a producer of human food, is the most economical. The human food value of these animal products as compared with wheat and corn is not great enough to justify changing the grains, which themselves may be eaten by man, to animal products.

What then is to be done? Do such calculations mean that we must turn vegetarians and forego the satisfaction of animal products in our diet? Not exactly. They rather indicate that our method of producing animal products must be changed. There are vast amounts of coarse rough feeds unfit for human consumption which can be fed to livestock and thus concentrated, so to speak, into suitable human food. It is in this role of concentrators of low-grade material that farm livestock reach their highest service to mankind. Of the total corn crop, for example, nearly one half of the food nutrients occur in the fodder. The same is true of the wheat crop and other cereals.

Wisdom and economy suggests that the more refined and concentrated portion of the plants (the kernels) which are suitable for human food should be so used, and that the coarser portions (the straws, fodders, etc.) together with the hay crops should be fed to the various classes of livestock and thus concentrated into human food.

It is, of course, not profitable to use these coarse feeds entirely, but mill by-products are available which are not suitable for human food and yet are well adapted to feeding livestock. Then, too, for the present and possibly for years to come, it will be profitable to use some grain in livestock feeding. The course of greatest ultimate economy, however, is to use the animals to reduce and transform the coarse rough material and the mill by-products, all of which can not be used directly as human food and would otherwise be wasted, into animal products to supplement the human food materials obtained from the plant kingdom. This system not only utilizes more completely and economically the various direct and indirect sources of human food supply, but in addition affords the variety so essential to the human diet.

The general adoption of such a system will indeed bring about man's "dominion over the cattle, and over all the earth."

APPENDIX

TABLE I—REQUIREMENTS FOR GROWTH WITH NO CONSIDERABLE FATTENING*

Per Day and Head, Including Maintenance

(1) Cattle

Age	BEEF BREEDS			DAIRY BREEDS		
	Live Weight	Digestible True Protein	Net Energy	Live Weight	Digestible True Protein	Net Energy
Months	Pounds	Pounds	Therms	Pounds	Pounds	Therms
1	125	0.70	3.7	100	0.40	3.1
2	175	0.85	4.2	135	0.45	3.4
3	200	0.90	4.2	165	0.55	3.6
6	350	1.15	5.0	275	0.70	4.1
9	450	1.25	5.7	325	0.75	4.4
12	550	1.40	6.5	400	0.80	5.1
18	750	1.40	8.2	550	0.85	6.4
24	900	1.30	9.3	700	0.85	7.6
30	1000	1.30	9.9	800	0.85	8.2

(2) Sheep

Age	WOOL BREEDS			MUTTON BREEDS		
	Live Weight	Digestible True Protein	Net Energy	Live Weight	Digestible True Protein	Net Energy
Months	Pounds	Pounds	Therms	Pounds	Pounds	Therms
3	37	0.13	0.78	40	0.22	0.84
6	65	0.18	0.95	72	0.30	1.03
9	82	0.17	1.06	98	0.28	1.22
12	90	0.15	1.12	115	0.25	1.36
18	100	0.12	1.19	150	0.22	1.64

(3) Swine

Age	Live Weight	Digestible True Protein	Net Energy
Months	Pounds	Pounds	Therms
1	15	0.10	0.65
2	30	0.20	1.00
3	52	0.30	1.38
6	118	0.40	2.28
9	183	0.50	3.06
12	250	0.55	3.80

*Armsby's, "The Nutrition of Farm Animals", p. 713.

TABLE II—REQUIREMENTS FOR FATTENING*
PER HEAD AND DAY

(1) Cattle

Assuming a Daily Gain of 2 pounds a head

Live Weight	In Early Stages: Digestible True Protein	In Early Stages: Net Energy	In Late Stages: Digestible True Protein	In Late Stages: Net Energy
Pounds	Pounds	Therms	Pounds	Therms
500	0.80	8.78	.60	11.78
750	1.06	9.95	.86	12.95
1000	1.30	11.00	1.10	14.00
1250	1.56	11.96	1.36	14.96

(2) Sheep

Assuming a daily gain of 0.25 pounds a head

Live Weight	In Early Stages: Digestible True Protein	In Early Stages: Net Energy	In Late Stages: Digestible True Protein	In Late Stages: Net Energy
Pounds	Pounds	Therms	Pounds	Therms
40	0.079	1.055	0.054	1.43
60	0.100	1.185	0.075	1.56
80	0.121	1.305	0.096	1.63
100	0.142	1.415	0.117	1.79
120	0.163	1.515	0.138	1.89

(3) Hogs

Assuming a daily gain of 1.5 pounds a head

Live Weight	In Early Stages: Digestible True Protein	In Early Stages: Net Energy	In Late Stages: Digestible True Protein	In Late Stages: Net Energy
Pounds	Pounds	Therms	Pounds	Therms
100	0.323	5.00	0.173	7.25
120	0.343	5.16	0.193	7.41
140	0.362	5.31	0.212	7.56
160	0.382	5.46	0.232	7.71

*Calculated from Armsby's "The Nutrition of Farm Animals."

TABLE III—REQUIREMENTS FOR MILK PRODUCTION*

	Digestible True Protein	Net Energy
Dairy Cows.	Pounds	Therms
For maintenance of 750-lb. cow	0.38	4.95
For maintenance of 1000-lb. cow	0.50	6.00
For maintenance of 1250-lb. cow	0.63	6.96
Add to the maintenance requirements the following amounts for each pound of milk of the several grades.		
Grade of Milk Per Cent Fat		
3.0	0.043	0.214
3.5	0.045	0.238
4.0	0.049	0.265
4.5	0.052	0.291
5.0	0.055	0.315
5.5	0.058	0.338
6.0	0.061	0.361
6.5	0.064	0.385
7.0	0.068	0.408

*Armsby's "The Nutrition of Farm Animals," pp. 711, 714.

TABLE IV—REQUIREMENTS FOR WORK PRODUCTION BY THE HORSE*

Per 1000 Pounds Live Weight

	Digestible True Protein	Net Energy
	Pounds	Therms
Full work—8 hours per day	2.0	18.2
Half work—4 hours per day	1.4	11.1
One fourth work—2 hours per day	1.0	7.6

*Armsby's, "The Nutrition of Farm Animals", p. 714.

TABLE V—VALUES PER 100 POUNDS FOR RUMINANTS*

	Dry Matter	DIGESTIBLE Crude Protein	DIGESTIBLE True Protein	Net Energy Value
DRIED ROUGHAGE				
Hay and fodder from cereals	Pounds	Pounds	Pounds	Therms
Brome grass, smooth	91.5	5.0	3.5	40.83
Corn (maize) fodder (ears included, medium dry)	81.7	3.0	2.3	43.94
Corn (maize) stover (ears removed, medium dry)	81.0	2.1	1.6	31.62
Mixed timothy and clover	87.8	5.3	3.6	40.85
Oat hay	88.0	4.5	3.9	32.25
Orchard grass	88.4	4.7	3.3	44.93
Prairie hay	93.5	4.0	2.9	40.42
Red top	90.2	4.6	3.9	51.22
Timothy, all analyses	88.4	3.0	2.2	43.02
Hay and fodder from legumes				
Alfalfa, all analyses	91.4	10.6	7.1	34.23
Clover, alsike	87.7	7.9	5.3	34.42
Clover, red, all analyses	87.1	7.6	4.9	38.68
Clover, sweet white	91.4	10.9	6.7	38.98
Cowpeas, all analyses	90.3	13.1	9.2	37.59
Soy beans	91.4	11.7	8.8	44.03
Straws				
Barley	85.8	0.9	0.6	36.61
Oats	88.5	1.0	0.8	34.81
Rye	92.9	0.7	0.5	17.59
Wheat	91.6	0.7	0.3	7.22
FRESH GREEN ROUGHAGE				
Green cereals, etc.				
Blue grass, Kentucky, before heading	23.8	3.7	2.8	14.82
Corn (maize) fodder, flint, all analyses	20.7	1.0	0.8	13.53
Oat fodder	26.1	2.3	2.0	14.06
Orchard grass	29.2	1.7	1.1	15.81
Wheat fodder	27.4	2.8	1.9	18.75
Green legumes				
Alfalfa, in bloom	25.9	3.3	1.8	11.50
Clover, red, all analyses	26.2	2.7	1.7	15.87
Peas, Canada field	16.6	2.9	2.1	9.78
SILAGE				
Corn (maize), well-matured, recent analyses	26.3	1.1	0.6	15.90
Clover	27.8	1.3	0.8	7.26
Sugar beet pulp	10.0	0.8	0.5	9.32
ROOTS, TUBERS, AND FRUITS				
Apples	18.2	0.4	0.1	15.92
Beets, sugar	16.4	1.2	0.4	11.20
Carrots	11.7	0.9	0.5	9.21
Mangels	9.4	0.8	0.1	5.68
Potatoes	21.2	1.1	0.1	18.27
Pumpkins, field	8.3	1.1	0.6	6.05
Rutabagas	10.9	1.0	0.3	8.46
Turnips	9.5	1.0	0.4	6.16

	Dry Matter	DIGESTIBLE Crude Protein	DIGESTIBLE True Protein	Net Energy Value
	Pounds	Pounds	Pounds	Therms
GRAINS				
Cereal grains				
Barley	90.7	9.0	8.3	89.94
Corn (maize), flint	87.8	7.7	7.2	84.00
Corn (maize) meal	88.7	6.9	6.4	85.20
Oats	90.8	9.7	8.7	67.56
Rye	90.6	9.9	9.0	93.71
Wheat, all analyses	89.8	9.2	8.1	91.82
Leguminous seeds				
Peas, field	90.8	19.0	16.6	78.72
DAIRY PRODUCTS				
Buttermilk	9.4	3.4	3.4	13.32
Cow's milk	13.6	3.3	3.3	29.01
Skim milk—centrifugal	9.9	3.6	3.6	14.31
Whey	6.6	0.8	0.8	10.39
BY-PRODUCTS				
Milling				
Wheat bran	89.9	12.5	10.8	53.00
Wheat middlings, standard	89.6	13.4	12.0	59.10
Oil extraction				
Cottonseed meal, choice	92.5	37.0	35.4	93.46
Linseed meal, old process	90.9	30.2	28.5	88.91
Sugar manufacture				
Molasses, beet	74.7	1.1	0.0	57.10
Molasses, beet pulp	92.4	5.9	3.5	76.28
Sugar beet pulp, dried	91.8	4.6	0.7	75.87
Sugar beet pulp, ensiled	10.0	0.8	0.5	9.32
Packing house				
Tankage—over 60 per cent protein	92.6	58.7	55.6	93.04

*Selected from Armsby's, "The Nutrition of Farm Animals," pp. 715-721.

TABLE VI—VALUES PER 100 POUNDS FOR THE HORSE*

	Dry Matter	DIGESTIBLE Crude Protein	True Protein	Energy Value
	Pounds	Pounds	Pounds	Therms
Alfalfa hay	91.4	10.9	7.4	48.82
Red clover hay	87.1	7.2	4.5	39.94
Timothy hay	88.4	1.3?	0.5?	26.64
Wheat straw	91.6	0.8	0.4	20.90
Oats	90.8	9.9	8.9	93.44
Carrots	11.7	1.2	0.8	16.60

*Selected from Armsby's, "The Nutrition of Farm Animals", p. 721.

TABLE VII—VALUES PER 100 POUNDS FOR SWINE*

	Dry Matter	DIGESTIBLE Crude Protein	True Protein	Net Energy Value
	Pounds	Pounds	Pounds	Therms
Barley	90.7	8.8	8.1	106.08
Corn (maize), dent	89.5	7.6	7.1	118.82
Rye	90.6	9.9	9.0	123.68
Wheat	89.8	9.9	8.8	108.85
Wheat bran	89.9	12.0	10.3	74.95
Wheat middlings, standard	89.5	14.4	12.7	103.73
Tankage, over 60 per cent protein	92.6	44.8	41.7	109.39
Skim milk	9.9	3.8	3.8	14.74

*Selected from Armsby's, "The Nutrition of Farm Animals", p. 722.

TABLE VIII—RELATIVE VALUE OF FEEDING STUFFS BASED ON THEIR CONTENT OF DIGESTIBLE MATTER, NET ENERGY, AND FEED UNITS

		Digestible Matter		Net Energy		Feed Units	
	Price per Cwt.	In 100 lbs.	Cost per lb.	In 100 lbs.	Cost per Therm	In 100 lbs.	Cost per unit
	cents	lbs.	cents	therms	cents		cents
Wheat Bran	110	60.9	1.81	53.00	2.08	90.9	1.21
	120		1.97		2.26		1.32
	130		2.13		2.45		1.43
	140		2.30		2.64		1.54
	150		2.46		2.83		1.65
	160		2.63		3.02		1.76
Wheat Shorts	130	78.2	1.66	75.02	1.73	100	1.30
	140		1.79		1.87		1.40
	150		1.92		2.00		1.50
	160		2.05		2.13		1.60
	175		2.24		2.33		1.75
	200		2.56		2.67		2.00
Wheat	100	81.5	1.23	91.82	1.09	100	1.00
	125		1.53		1.36		1.25
	150		1.84		1.63		1.50
	175		2.15		1.91		1.75
	200		2.45		2.18		2.00
	225		2.76		2.45		2.25
	250		3.07		2.72		2.50
	300		3.68		3.27		3.00
Corn (Dent)	150	85.7	1.75	85.50	1.75	100	1.50
	200		2.33		2.34		2.00
	225		2.63		2.63		2.25
	250		2.92		2.92		2.50
	300		3.50		3.51		3.00
Barley	110	79.4	1.39	89.94	1.22	100	1.10
	125		1.57		1.39		1.25
	150		1.89		1.67		1.50
	175		2.20		1.95		1.75
	200		2.52		2.22		2.00
	225		2.83		2.50		2.25
	250		3.15		2.78		2.50
Oats	130	70.4	1.85	67.56	1.92	90.9	1.43
	150		2.13		2.22		1.65
	175		2.49		2.59		1.92
	200		2.84		2.96		2.20
	225		3.20		3.33		2.48
	250		3.55		3.70		2.75
Tankage over 60 per cent Protein	300	87.0	3.45	93.04	3.22		
	350		4.02		3.76		
	400		4.60		4.30		
	450		5.17		4.84		
	500		5.75		5.37		
	550		6.32		5.91		
	600		6.90		6.45		

	Price per Cwt.	Dibestible Matter In 100 lbs.	Dibestible Matter Cost per lb.	Net Energy In 100 ibs.	Net Energy Cost per Therm	Feed Units In 100 lbs.	Feed Units Cost per unit
Choice Cottonseed Meal	275	78.2	3.52	93.46	2.94	125.0	2.20
	300		3.84		3.21		2.40
	325		4.16		3.48		2.60
	340		4.35		3.64		2.72
	350		4.48		3.74		2.80
	360		4.60		3.85		2.88
	400		5.12		4.28		3.20
Alfalfa Hay	50	51.6	.97	34.23	1.46	50.0	1.00
	60		1.16		1.75		1.20
	70		1.36		2.04		1.40
	80		1.55		2.34		1.60
	90		1.74		2.63		1.80
	100		1.94		2.92		2.00
	115		2.23		3.36		2.30
	130		2.52		3.80		2.60
Clover Hay	50	50.9	.98	38.68	1.29	50.0	1.00
	60		1.18		1.55		1.20
	70		1.37		1.81		1.40
	80		1.57		2.07		1.60
	90		1.77		2.33		1.80
	100		1.96		2.59		2.00
	115		2.26		2.97		2.30
	130		2.55		3.36		2.60
Timothy Hay	50	48.5	1.03	43.02	1.16	33.3	1.50
	60		1.24		1.39		1.80
	70		1.44		1.63		2.10
	80		1.65		1.86		2.40
	90		1.86		2.09		2.70
	100		2.06		2.32		3.00
Wild Hay (from wet lands)	20	45.4	.44			25.0	.80
	30		.66				1.20
	40		.88				1.60
	50		1.10				2.00
	60		1.32				2.40
	70		1.54				2.80
Oat Straw	5	45.6	.11	34.81	.14	20.0	.25
	10		.22		.29		.50
	15		.33		.43		.75
	20		.44		.57		1.00
	25		.55		.72		1.25
	30		.66		.86		1.50
Wheat Straw	5	36.9	.14	7.22	.69	18.0	.28
	10		.27		1.39		.56
	15		.41		2.08		.83
	20		.54		2.77		1.11
	25		.68		3.46		1.39
	30		.81		4.16		1.67

		Digestible Matter		Net Energy		Feed Units	
	Price per Cwt.	In 100 lbs.	Cost per lb.	In 100 lbs.	Cost per Therm	In 100 lbs.	Cost per unit
Corn Stover	10	52.2	.19	31.62	.31	25.0	.40
	15		.29		.47		.60
	20		.38		.63		.80
	25		.48		.79		1.00
	30		.57		.95		1.20
	35		.67		1.11		1.40
Sugar Beets	1.5	14.0	1.07	11.20	1.34	14.3	1.05
	2.0		1.43		1.79		1.40
	2.5		1.79		2.23		1.75
	3.0		2.14		2.68		2.10
	3.5		2.50		3.13		2.45
	4.0		2.86		3.57		2.80
Mangels	10	7.4	1.35	5.68	1.76	8.0	1.25
	15		2.03		2.64		1.88
	20		2.70		3.52		2.50
	25		3.38		4.40		3.13
	30		4.05		5.28		3.75
	35		4.72		6.16		4.38
Carrots	10	9.9	1.01	9.21	1.09	12.5	.80
	15		1.52		1.63		1.20
	20		2.02		2.17		1.60
	25		2.53		2.71		2.00
	30		3.03		3.26		2.40
	35		3.54		3.80		2.80
Beet Pulp	15	8.0	.19	9.32	.16	8.0	.19
	20		.25		.21		.25
	25		.31		.27		.31
	30		.38		.32		.38
	35		.44		.38		.44
	40		.50		.43		.50
Corn Silage	10	17.7	.57	15.90	.63	16.7	.60
	15		.85		.94		.90
	20		1.13		1.26		1.20
	25		1.41		1.57		1.50
	30		1.69		1.89		1.80
	35		1.98		2.20		2.10
Skim-Milk	5	9.1	.55	14.31	.35	16.7	.30
	10		1.10		.70		.60
	15		1.65		1.05		.90
	20		2.20		1.40		1.20
	25		2.75		1.75		1.50
	30		3.30		2.10		1.80
	35		3.85		2.45		2.10
	40		4.40		2.80		2.40